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ORIGINAL ARTICLE

Second generation Guepar total arthroplasty of the thumb basal joint: 50 months follow-up in 84 cases

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Accepted: 19 June 2008

KEYWORDS

Thumb basal joint
osteoarthritis;
First
carpometacarpal
(CMC) joint GUEPAR
arthroplasty

Summary

Background. – Osteoarthritis of the thumb basal joint is the most common location for hand degenerative joint disease. First, carpometacarpal (CMC) joint arthroplasty is one treatment option. The purpose of this article is to present the outcome of the GUEPAR II prosthesis, a total trapeziometacarpal cemented implant of the retaining ball-and-socket design type. Numerous other advantageous features of this implant, second generation of an earlier version are explored.

Hypothesis. – Clinical and radiological results confirm the GUEPAR II trapeziometacarpal arthroplasty as a reliable and efficient evolution of earlier prosthetic designs.

Materials and methods. – Eighty-four GUEPAR II prostheses were implanted to treat advanced and severely incapacitating first CMC osteoarthritis. The average follow-up time in this collaborative series (from 2 centers) was 50 months.

Results. – There were no intraoperative complications and no dislocations at the final follow-up evaluation, 92% of patients were satisfied or very satisfied with their results with objective improvement of their Kapandji score. Strength was closely comparable to the nonaffected side. Radiographic studies at the final follow-up evaluations did not show (except in one socket revision instance) signs of implant loosening. On occasion, non-progressive radiolucent lines were observed. More than 80% of the patients remained pain free.

Conclusions. – In our series, GUEPAR II total joint arthroplasty of the thumb CMC joint has proven to be efficacious, improving motion, strength, and achieving a high degree of pain relief. Successful outcome appears in our experience contingent upon strict compliance with numerous surgical technique details. Current research focuses on improving bipolar fixation by developing press-fit cementless implants.

Level of evidence: level IV; therapeutic study.

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Introduction

Described by Forestier [1] in 1937, basal thumb osteoarthritis is a disease that is frequently encountered in surgery of the hand. Treating it surgically can require a variety of techniques [2]:

- trapeziectomy with or without interposition and with or without ligamentoplasty, which can shorten the first column and result in loss of thumb force;
- trapeziometacarpal arthrodeses, sacrificing part of the thumb column's range of movement;
- implant arthroplasties using prostheses.

The trapeziometacarpal joint of the thumb is an inverse toroid-shaped joint or a saddle joint that is mechanically similar to a universal joint. There is an automatic pronation movement (axial rotation) of the first column during opposition movements [3]. A patella-type spheroid joint is therefore an approximation, with more freedom (3 degrees of freedom versus 2 with automatic rotation) than the native trapeziometacarpal joint [4].

The objective of this study was to assess the results obtained for this arthroplasty and the benefits expected compared to other surgical techniques.

Patients and methods

Implant

A second-generation GUEPAR trapeziometacarpal prosthesis is a pin-and-socket-type total prosthesis, with 3 degrees of freedom, a trapezoidal center of rotation, and two cemented components [5].

The metacarpal stem is an anatomic, conic component that is triangular in its cross-section; it fills the medullary canal and its collar rests against the metacarpal surface. This design blocks the stem both in rotation and vertically in the metacarpal axis. The stem is monobloc, smooth, and manufactured in chrome–cobalt. Four sizes are available, with length varying from 24 to 27 mm and the maximal width varying from 8 to 11 mm. The stems are not incrementally sized. The neck of the implant is in the stem's axis. There are two neck lengths: 4 and 6 mm, the neck is slender, smooth, polished, and shiny. The head's diameter is 5 mm (Fig. 1).

The trapezoidal cup is made of polyethylene, available in a retentive and nonretentive form. Its outer diameter is 9 mm in the distal axis and 8 mm in the proximal axis, and it is 6.5 mm high [6]. This socket enables 50° range of motion, less than other available implants. However, its range of motion is close to physiological range of motion and it is associated with a retentive cup, solving the instability problem of certain trapeziometacarpal implants [7].

Patients

This retrospective series include 84 prostheses implanted in 68 patients, in two university-affiliated hospitals (Hôpital Bichat in Paris and the Lille University Hospital) between 1995 and 2004.



Figure 1 Second-generation GUEPAR prosthesis in four sizes for the metacarpal with two neck lengths and a single trapezoidal cup size.

Fifty-seven patients (72 prostheses) were reviewed by a single surgeon independent of the operators; 11 patients (12 prostheses) were contacted by telephone because they could not attend a consultation.

The series (55 females and 13 males) included a majority of women (82%). The mean age at surgery was 61 years (range: 46–77 years), the median was 60 years. The dominant side was operated on in 52% of the cases. Fifty-five patients (80%) had bilateral basal thumb osteoarthritis. Of these 55 patients, 27 had not had surgery on the opposite side. The mean Dell stage was 2.3 [8]. Stage I was observed in two cases, stage II in 53 cases, stage III in 27 cases, and stage IV in two cases (Table 1). As a consequence, 65% of the series was observed to have concentric basal

Table 1 Dell's radiological classification of peritrapezial osteoarthritis.

Stage 1	Normal joint Beginning joint space narrowing Subchondral condensation No subluxation, no osteophyte
Stage 2	Joint space narrowing Condensation Subluxation < 1/3 width of joint surface
Stage 3	Pronounced joint space narrowing Prominent osteophyte Subluxation > 1/3 width of joint surface Possible peritrapezial osteoarthritis
Stage 4	Loss of joint contour Prominent osteophyte Substantial subluxation or dislocation Frequent peritrapezial osteoarthritis

Table 2 Alnot's pain classification.

Stage 0	No pain
Stage 1	Pain during significant effort
Stage 2	Pain during daily activities
Stage 3	Spontaneous intermittent pain
Stage 4	Continuous pain

thumb osteoarthritis and 35% had eccentric basal thumb osteoarthritis.

The mean follow-up of the series was 50 months (range: 12–115 months), with a median of 46.5 months.

Primary osteoarthritis was the only cause of osteoarthritis in this series. We found carpal tunnel syndrome that required surgical treatment in 21 cases. Among the associated pathologies, we also found seven cases of trigger thumb. In cases of bilateral trapeziometacarpal arthroplasty, the two sides were never operated on at the same time, but with a minimum three-month delay.

Trapeziometacarpal arthroplasty had been decided in cases of painful basal thumb osteoarthritis that was resistant to medical treatment (longer than 6 months). The criteria considered in making the decision for this technical choice were age over 50 years, no need for intensive hand activity, and trapezial height greater than 8 mm so that the trapezial cup and its cement mantle could be fit properly [9]. The mean duration of symptoms before surgery was 38 months (range: 2–180 months). Fifty-two trapeziometacarpal joints had had an infiltration of cortisone derivatives, with a mean of 1.6 cortisone derivative infiltrations [1–7]. Fifty-five patients (66%) had worn a thumb splint and 15% of the patients had had preoperative physical therapy.

Revision

Revision was based on three clinical criteria (residual pain, range, and force) and the usual radiographic anomalies (line, osteolysis, loosening, and wear).

The residual pain was classified according to Alnot and Muller [2] (Table 2). Range was evaluated using the Kapandji score [10], which grades the opposition of the thumb's pulp with the pulp of the long fingers on a scale ranging from 1 to 10. Force was measured using a Jamar dynamometer evaluating grasp force, end-to-side pinch force (key-pinch test), and end-to-end pinch force (pulp-pinch test).

From a radiographic point of view, the intermetacarpal M1–M2 angle was measured on strictly PA X-rays of the hand in maximum abduction. Lateral and PA X-rays of the thumb were used to quantify the radiolucent lines (defined by a submillimeter radiotransparent space between the cement sheath and the cancellous bone, with no mobilization of the implant components) and loosening (X-ray images

demonstrating any patent mobilization of the implant material, in any direction or range of motion). Stem impaction was assessed by comparing the relations of the implant length versus the total length of the first metacarpal on the postoperative X-ray and the follow-up X-ray. Trapezial cup movement was evaluated by comparing the angle between the metallic cerclage and the axis of the proximal cortex of the trapezium (subchondral bone of the scaphoid surface) on the immediate postoperative and follow-up X-rays.

Statistical analysis

The statistical analysis software used was SPSS® 13.0 (2004) for Windows. Descriptive statistics calculated the means and standard deviations. Since the number of patients was close to 100, we also expressed the number as a percentage to facilitate comprehension. The Student *t*-test was used to compare the quantitative or ordinal variables between two groups (matched and unmatched) that contained more than 30 patients. The Mann-Whitney nonparametric test was used to compare the quantitative or ordinal variables between two unmatched groups with fewer than 30 members. The Pearson correlation coefficient was calculated when the number of patients exceeded 30; it was followed by an appropriate Student *t*-test to test this correlation. The Fisher exact test was used to test two qualitative binary variables when the theoretical number of patients was less than five.

The difference was considered statistically significant when the *p*-value was less than 0.05.

The conditions in which the statistical tests were applied were verified for each of the tests; however, it was impossible to confirm with certainty the absence or presence of correlated variables because of the low numbers of patients in certain groups, notably for the group of patients experiencing loosening. Since the study was retrospective, we could not estimate the beta risk, that is, the risk of not finding a significant difference even though such a difference existed.

Results

Pain

According to the Alnot and Muller classification [2], pain at follow-up was absent (stage 0) in 50 patients (60%), stage 1 (during significant effort) in 15 patients (18%), stage 2 (during daily activities) in 11 patients (15%), stage 3 (spontaneous intermittent pain) in six patients (7%), and stage 4 (continuous pain) in two patients (2%) (Table 3). The mean postoperative pain score was 0.7, whereas it was 3.5 before surgery. The difference was highly statistically signif-

Table 3 Pre- and postoperative pain stages according to Alnot and Muller's classification.

Pain	Stage 0	Stage 1	Stage 2	Stage 3	Stage 4
Preoperative	0	1 (1)	9 (11)	24 (29)	50 (59)
Postoperative	50 (60)	15 (18)	11 (13)	6 (7)	2 (2)

The numbers in parentheses represent percentages of the series.

icant (Student *t*-test on matched samples, $p < 0.0001$). Pain was not influenced by implant loosening (cup, metacarpal stem or bipolar loosening) (Mann-Whitney test, respectively, $p = 0.47$, $p = 0.21$, $p = 0.25$).

Range

The mean Kapandji score after surgery was 9.5 ± 1.2 ; 91% of patients had a score of 8 or higher. The preoperative Kapandji score was 8.8 ± 1.5 . The difference was highly significant (Student *t*-test on paired samples, $p < 0.005$). A clear correlation was found between the postoperative Kapandji score and trapezial cup loosening ($p = 0.008$). Cup loosening had a very negative influence on the Kapandji score at follow-up.

Force

The mean forces on the operated side and the opposite side were 6 ± 2.7 kgf versus 5.8 ± 2.3 kgf, respectively, for end-to-side pinch, 4 ± 2.1 kgf versus 4.2 ± 1.7 kgf for end-to-end pinch, and 20.8 ± 9.5 kgf versus 20.4 ± 9.8 kgf for grasp. None of these three differences was statistically significant (Student *t*-test on paired samples, $p = 0.523$, $p = 0.318$, $p = 0.6$, respectively). Patient age was also not significantly correlated with force on the operated side as determined by the three force tests (Pearson correlation coefficients: $r = -0.094$, $r = -0.133$, $r = -0.135$ corresponding to $p = 0.47$, $p = 0.32$, $p = 0.29$, respectively). Cup, metacarpal stem or bipolar loosening was not correlated with force on the operated side as determined by the three above-mentioned tests (Mann-Whitney test, cup loosening: $p = 0.6$, $p = 0.68$, $p = 0.1$, respectively; stem loosening: $p = 0.73$, $p = 0.66$, $p = 0.1$, respectively; bipolar loosening in a single patient, which precluded the statistical analysis).

Metacarpophalangeal joint

At follow-up, 25% of the patients presented intermittent pain in the thumb's metacarpophalangeal (MCP) joint. Pain was accompanied by lateral laxity in 50% of these cases.

Twenty-four percent of the patients presented laxity in the thumb's MCP joint. Laxity was accompanied by pain of the MCP (MCP) joint of the thumb in 53% of the cases. Sixty-six patients (79%) had no MCP hyperextension, 14 patients (17%) showed reducible MCP hyperextension between 10° and 30° , and only four patients (4%) showed passively reducible MCP hyperextension greater than 40° .

Overall satisfaction

Ninety-two percent of the patients stated that they were satisfied or very satisfied with the results. The patients who had undergone surgery on the dominant side seemed more satisfied than those who had had surgery on the nondominant side ($p = 0.03$). The preoperative Kapandji score had no influence on the degree of postoperative satisfaction ($p = 0.1$).

Radiographic study

The mean maximal M1–M2 abduction angle was $37^\circ \pm 11$ (range: 10° – 60°) versus $35^\circ \pm 9$ before the arthroplasty (range: 20° – 55°).

Lucent lines were found in 33% of the patients: 28% trapezial lucent lines and 5% bipolar lucent lines (Fig. 2). Trapezial cup loosening affected 3% of the series (Fig. 3). Metacarpal stem loosening affected 3% of the series (Fig. 4A, B). The cases of loosening observed for the most part occurred early (appearing in the first 6 postoperative months) and in these cases they were related to a technical problem (misalignment of trapezial reaming, poor



Figure 2 X-ray showing a complete lucent line around the trapezial cup in an asymptomatic patient.



Figure 3 X-rays showing complete loosening of the trapezial cup. Occasional pain, Kapandji score, 8; grasp test, 18 kgf.



Figure 4 X-rays showing loosening of the metacarpal component (4A). The small amount of cement can also be seen (4B) and the initial filling of the medullary canal may be insufficient. Patient with no pain, Kapandji score, 9; grasp test, 22 kgf.

cementing of the metacarpal stem). We found no correlation between age and loosening (Mann-Whitney test, cup, stem, and bipolar loosening, respectively: $p=0.553$, $p=0.39$, $p=0.213$) or between sex and loosening (Fisher exact test, cup, stem, and bipolar loosening, respectively: $p=0.372$, $p\approx 1$, the single patient in the last group precluded statistical analysis). The type of cup used (retentive or nonretentive) was not correlated with the proportion of cases with cup loosening (Fisher exact test; $p\approx 1$).

The preoperative Dell stage, reflecting whether the osteoarthritis of the thumb base was concentric or eccentric, was not correlated with loosening (Mann-Whitney test, cup, stem, and bipolar loosening, respectively: $p=0.176$, $p=0.749$, the single patient precluded statistical analysis). In other words, the misalignment of the base of the first metacarpal did not seem to increase the strains on the cup and its loosening. Weakening of the lateral cortical bone (lateral wall) of the trapezium was very strongly correlated with the onset of cup loosening ($p < 0.0001$).

These statistical results should be considered cautiously because of the small number of patients.

In total, 55% of the X-ray images were strictly normal, with no sign of loosening, and with no lucent lines or ossifications.

During the analysis of the follow-up images, the persistence of a medial osteophyte in the trapezium that could conflict with the neck of the metacarpal implant was noted in 44% of the cases and no osteophyte in 56% of the cases (Fig. 5).

Complications

In this series, no intraoperative metacarpal or trapezial fractures or dislocations of the implant were found. In addition, we observed no subluxation between implant components



Figure 5 PA X-ray, Kapandji incidence. Persistence of a medial osteophyte of the trapezium. Asymptomatic patient.

in cases of loosening with implant mobilization, which confirms that the trapezial cups were retentive. We had no cases of secondary ossification in the prosthetic joint. However, three cases of type 1 complex pain syndrome (algodystrophy) appeared. We observed no superficial or deep infection and no allergies to the prosthetic materials.

A secondary rupture of the extensor pollicis longus tendon occurred in one patient six weeks postoperatively, leading to a transfer of the index's extensor tendon; the patient seemed satisfied with the final result of the two interventions. No sensory problems of the dorsal side of the thumb were observed.

A single surgical revision was necessary at 15 months after surgery, because of persistent pain secondary to cup loosening. Surgery consisted of trapeziectomy associated with ablation of the metacarpal stem without removing the cement and a ligamentoplasty with interposition of the carpal radial flexor tendon [11], with no particular problems (notably, no problems removing the metacarpal stem). The patient was seen at follow-up and seemed satisfied with the result obtained, identical to the result of a first-intention trapeziectomy.

Discussion and conclusion

The advantages and disadvantages of the other surgical techniques in basal thumb osteoarthritis (trapeziectomy, arthroplasty with silicon implant, trapeziometacarpal arthrodesis) are well established today [2]. Patients are generally satisfied with the results of trapeziectomy, because this procedure provides adequate function: pain is lessened and pinch force is frequently acceptable. However, the final results of the intervention generally take longer to obtain (6 months) than with total arthroplasty. The inevitable shortening of the thumb is accompanied by altered dexterity and the first commissure progressively closes, leading to compensatory hyperextension of the MCP joint, mimicking the

natural progression of untreated basal thumb osteoarthritis [6].

Arthrodesis is a solution frequently used in North America and Great Britain. Patients often see their pain disappear with this procedure, their gripping force is often preserved, and thumb stability is good. However, the fusion achieved with arthrodesis is often delicate to obtain and prolonged immobilization is not rare. Thumb dexterity is altered by the reduction in its range and patients find it difficult to put on gloves and lay their hand flat. Over the more or less long term, onset of scaphotrapezotrapezoid joint overload can be observed, a source of arthritic degeneration.

Silicon implants have been somewhat abandoned in basal thumb osteoarthritis over the past few years. In a recent article, Minami et al. [12] reported that after analysis of the long-term results on silicon implants, they advised against their use because of implant subluxation, implant fractures, and osteolysis secondary to nonspecific immunological synovitis.

Total trapeziometacarpal arthroplasty is effective for pain. Most authors find approximately 80% of their patients with no pain or very little pain, which was also the case in our series (60% with strictly no pain, 18% with pain during significant effort) [13–15].

In our series, as has been published in a number of studies, pain was not correlated with implant loosening ($p=0.2$) [16]. This difference in radiological and clinical evidence remains difficult to explain, because implant mobilization is usually painful in other joint sites with implants. This suggests that annual radiological and clinical monitoring of these patients would be useful, without waiting for symptoms to appear.

As for range-of-motion scores, the Kapandji score, the most frequently used, is between 9 and 10 for all types of implant [17–19]. In our series, the mean Kapandji score was 9.2; 91% of the patients had a score greater than or equal to 8 and 65% had a score equal to 10. It is interesting to note that implants proposing greater arc of motion than the GUEPAR implant did not seem to provide greater thumb range, but are exposed to dislocations.

For some, lucent lines are a precursor sign of loosening. In our series, the lucent lines found were consistently less than 1 mm and appeared stable over time, to the point that today we doubt that they are pathological, even if the mean follow-up for this series remains relatively short. In many other series, the proportion of lucent lines (essentially trapezial) should be noted: from 4 to 52%, depending on the implants used and the length of follow-up, with a predominance of trapezial lucent lines [20,21]. The cementless prostheses also present lucent lines, which makes their osteo-integration in all cases doubtful [22].

As for loosening (cemented implants) or the absence of osteo-integration (cementless implants), the rate is also highly variable depending on the implants used and generally increases with the mean follow-up in the different series. For cemented prostheses, the rates vary from 10 (follow-up, 64 months) to 44% (follow-up, 102 months), with approximately three to four cases of trapezial loosening for one case of metacarpal loosening [21].

In the only series reporting an anatomic saddle prosthesis, Perez-Ubeda et al. [18] reported 55% loosening (for the most part trapezial) at 33 months of follow-up.

During a period when the surface conditions (smooth implants with no hydroxyapatite coating) were poorly adapted [22], the same observations were made concerning the cementless prostheses. However, since the design of the prostheses used herein was more recent, the follow-up periods of the available series is often shorter, although the rate of loosening increases with time [23].

Overall, cup loosening and lucent lines are more frequent than metacarpal implant loosening and lucent lines. Several etiological factors have been hypothesized:

- first, the contact surface between the implant and cancellous bone is much less on the trapezium than on the first metacarpal shaft;
- second, reaming may be more aggressive and, therefore, more devascularizing on the trapezium than on the first metacarpal.

The implants' anatomical support may also be at fault. First, the cortices of the trapezium are much thinner than the cortices of the first metacarpal shaft; therefore, providing a less sturdy support for the implant than the cortices of the first metacarpal. Second, the quantity of the cancellous bone is very low in the trapezium and is reduced even more by the reaming necessary to implanting the cup, which undoubtedly hinders the anchoring of the cement, becoming nearly cortical and, therefore, having lower mechanical quality than a cancellous bone anchoring system. Some authors have also questioned the use of cement because it increases local heat, but the series in the literature have shown a sufficient number of loosening incidents with cementless cups to challenge this claim. The theoretical advantages of cemented fixation compared to cementless fixations are reducing the risk of intraoperative fractures (impaction of cementless implants in small bones, often in osteoporotic female patients) as well as the problems with osteo-integration (risk of secondary subsidence). The cementless fixation seeks to provide a biological fixation that could be longer-lasting than the cemented fixation, but the small bone-implant contact (notably, at the trapezium) may not be particularly favorable. Overall, although fixation of the metacarpal stem is very frequently achieved (with cemented or cementless implants), the problem of trapezial cup fixation remains.

However, preservation of the lateral wall of the trapezium is indispensable for proper trapezial cup fixation. Maintaining the lateral walls of the trapezium seems to be an important factor in the stability of trapezial fixation. Weakening of the trapezium's lateral wall is highly correlated in our series with onset of cup loosening ($p < 0.0001$). Perfectly centered reaming of the trapezium is therefore indispensable, if necessary, using a landmark pin placed using the image intensifier.

We noted that metacarpal bone cementing was highly demanding in terms of quality. Indeed, with insufficient cementing, early mobilization of the metacarpal implants was observed. We therefore recommend retrograde cementing with pressure applied to the metacarpal component.

Dell's preoperative stage, showing whether the thumb osteoarthritis was concentric or eccentric, did not correlate with loosening (Mann-Whitney test, cup, stem, and bipolar loosening, respectively: $p=0.176$, $p=0.749$, a single indi-

vidual in the last group precluding statistical analysis). In other words, the base of the first metacarpal shaft being off-center did not seem to increase the strains on the cup and, therefore, its loosening.

In our series with the second-generation GUEPAR implant, we observed no dislocation. Dislocations are mainly described in series of nonretentive implants with wide range of motion: 10% for the ARPE implant depending on the series (120° range of motion, nonretentive) [19,23]. With the DLC prosthesis (retentive prosthesis with 85° range of motion), Moutet et al. [21] reported 5% dislocations, Chakrabarti et al. [17] found 2%, and Wachtl and Sennwald [24] observed 10%. This shows that, with time, wear of the polyethylene cup caused it to lose its retentiveness, resulting in dislocations, which we did not observe in our series.

Contrary to the weight-bearing joints (hip and knee), polyethylene wear does not seem to be a problem encountered in trapeziometacarpal prosthetic replacement, despite the thinness of the polyethylene. In our series, we did not observe misalignment of the implant head or osteolysis, but follow-up was limited to 50 months. The majority of the other trapeziometacarpal implant models use a metal–polyethylene friction couple and these complications have not been described in the literature on trapeziometacarpal prostheses.

Our series has a very low revision rate (1%). Loosening was only rarely combined with pain and did not always have important functional repercussions; hence, patients were not motivated to request a new intervention.

We are currently using cementless implants in an attempt to improve the bipolar fixation of this prosthesis.

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